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Documenting Marine Mammal Behavior and Evaluating the Benefits and Consequences of Viewing Marine Mammals in Southcentral Alaska

Lauren E. McCaslin

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DOCUMENTING MARINE MAMMAL BEHAVIOR AND EVALUATING THE
BENEFITS AND CONSEQUENCES OF VIEWING MARINE MAMMALS IN
SOUTHCENTRAL ALASKA

A Thesis
Presented to
The Faculty of the Department of Biology
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
Of the Requirements for the Degree
Master of Science

By
Lauren E. McCaslin

August 2019

DOCUMENTING THE BEHAVIOR OF MARINE MAMMALS AND EVALUATING
THE BENEFITS AND CONSEQUENCES OF VIEWING MARINE MAMMALS IN
SOUTHCENTRAL ALASKA

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I dedicate this thesis to my mom, Beth McCaslin.

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Marine mammals are in a precarious conservation position because of anthropogenic impacts and historic perceptions that they are a consumable commodity. In light of changing abiotic conditions, further evaluation is needed on the habitat use, behavior, and interactions among marine mammals. Conservation legislation has helped protect species, but the greatest ground swelling may be the advent of the commercial whale watching industry. The feeding grounds in Alaskan waters have made this area a prime tourism location, and these nutrient-rich waters have resulted in a confluence of marine mammal species, including the appealing and abundant humpback whale (*Megaptera novaeangliae*) that may associate with three ecotypes of killer whales (*Orcinus orca*). These species are interesting because they may travel together to feed on prey or be adversaries in a predator-prey relationship. Using whale watching as a platform, this study evaluated the effects of the presence of these two species separately and together, and of the type of interaction between them, on human perception. Data were collected via opportunistic observations and a retrospective pre- and post-survey instrument. Differences in humpback whale distribution and group size patterns were found relative to killer whale occurrence, although humpback whale behavioral states were unchanged. Changes in passenger conservation attitudes could not be attributed to species and behaviors but they were important determinates to whale watching

satisfaction. Overall, more positive conservation attitudes and an increase in knowledge about marine mammals were reported after whale watching. These tours provide an opportunity for collecting meaningful scientific data and providing more in-depth education such as enhancing the appreciation for ecosystem services provided by marine mammals.

CHAPTER 1:
EFFECTS OF KILLER WHALE OCCURRENCE ON HUMPBACK WHALE
HABITAT USE IN KENAI FJORDS, ALASKA

Introduction

Rapidly changing environmental conditions are affecting oceanic habitats, leaving the future of many marine mammal species in question (Reynolds III et al., 2009).

Conservation of marine mammals is critical to maintaining ecological balance in the world's oceans. To better conserve marine mammal species, evaluating their behavior as it relates to distribution and habitat use is necessary. Species of marine mammals range from fully aquatic cetaceans (whales, dolphins, and porpoises) and sirenians (manatees and dugongs), inhabiting saltwater, freshwater, and brackish water environments, to semiaquatic carnivores. Marine carnivores include pinnipeds (true seals, sea lions, fur seals, and walruses), sea otters, and polar bears, which use land, sea ice, or glacial ice for one or more of their life history phases, typically to breed, give birth, or molt (Jefferson et al., 2008). Marine mammals occupy a variety of habitats and are distributed across all latitudes. The geographic distribution of marine mammals follows a clumped pattern (Bowen & Siniff, 1999) and is largely driven by foraging and reproductive behaviors (Jefferson et al., 2008). These behaviors lead to some species undertaking long seasonal migrations, whereas others remain in one area throughout the year or partake in shorter migrations related to movements of their prey (Bjørge, 2002). The use of different habitats by marine mammals is influenced by myriad biotic and abiotic factors, and in

most cases, the patterns observed are due to a combination of these factors (Bowen & Siniff, 1999).

Physical conditions of a habitat, primarily currents, tides, temperature, salinity, and bathymetry play an important role in determining the geographic range of marine mammals (Bowen & Siniff, 1999; Jefferson et al., 2008). Distributions and habitat use of all marine mammal species are restricted by one or more of these physical conditions (Kaschner et al., 2006). The correlation between species occurrence and habitat use is dependent on species-specific niche requirements (Kashner et al., 2006), which not only involve physical constraints but also the ability of these physical factors to act in concert to create ‘topographically controlled fronts’ (Wolanski & Hamner, 1988). Fronts produced by physical oceanographic processes are known to directly affect the aggregation of small planktonic organisms, which in turn influence the habitat use of large predatory organisms such as marine mammals (Wolanski & Hamner, 1988; Bost et al., 2009). Studies examining the effects of oceanographic processes on habitat use by cetaceans have indicated habitat preferences based on current direction and tidal amplitude (Chenoweth et al., 2011) as well as bathymetry (Yen et al., 2004). Therefore, understanding how dynamic physical features of a habitat relate to its biological activity is necessary to evaluate marine mammal habitat use (Bost et al., 2009).

Biotic factors influencing marine mammal habitat use and distribution include interspecific and intraspecific interactions (Kaschner et al., 2006). The distribution and abundance of prey and predator species are important aspects relating to food availability and predation pressure, respectively (Kaschner et al., 2006). Predation on marine mammals can be attributed to humans (Read & Wade, 2000), sharks, and other marine

mammal species, most notably killer whales, polar bears, and leopard seals (Jefferson et al., 1991). Non-predatory interactions between species of marine mammals, as well as marine mammals and marine birds (Harrison, 1979) are also common. Examining interactions between marine mammals can help provide insight into reasons why habitats of similar quality are often used differently. As a migratory species with very few natural predators, humpback whales are an interesting model to study habitat use.

Humpback whales, *Megaptera novaeangliae*, are large baleen whales that undertake annual migrations from low-latitude winter breeding grounds to high-latitude summer feeding grounds (Bettridge et al., 2015). Three distinct population segments (DPS) of the North Pacific humpback whale (NPHW) migrate to the feeding grounds of southcentral Alaska. The majority of these whales are from the Hawaii DPS and the remainder are from the Mexico DPS and Second West Pacific DPS (Bettridge et al., 2015). North Pacific humpback whales show feeding site fidelity (Baker et al., 1986; Perry et al., 1990; Witteveen et al., 2011) and genetic studies have suggested strong maternal fidelity is responsible for these movements (Baker et al., 2013), although fidelity to feeding grounds is not complete in Alaska (Calambokidis et al., 1996). These whales feed on krill (*Euphausia pacifica*) and small schooling fish including sand lance (*Ammodytes hexapterus*), capelin (*Mallotus villosus*), and herring (*Clupea pallasii pallasii*). In general, feeding grounds are frequented by multiple species of cetaceans and marine carnivores. Therefore, the behavior and habitat use of humpbacks on their feeding grounds is likely to be shaped in part by both heterospecific and conspecific interactions.

Individual humpback whales can alter their use of a particular area in response to conspecific associations involving resource competition. Whitehead (1983) identified

mother-calf pairs, companionships, and feeding groupings as the main types of conspecific associations between humpbacks in Newfoundland. Humpback whales on feeding grounds have been known to form short-term associations of a particular group size and composition (Weinrich & Kuhlberg, 1991). Group sizes from one to more than 10 individuals have been observed although individuals and pairs are most common (Whitehead, 1983; Weinrich, 1991; Weinrich & Kuhlberg, 1991). The length of continuous associations varies from minutes to several months, and recurring associations have the ability to last across years (Weinrich, 1991). These associations are often related to feeding behaviors, allowing individuals to maximize their net energy gain through cooperative feeding techniques (Hain et al., 1982; Weinrich, 1991; Weinrich & Kuhlberg, 1991). However, these associations may be limited as both conspecifics and heterospecifics compete over resources.

On their feeding grounds in Kenai Fjords, Alaska, humpback whales are likely to encounter a number of other marine mammal species, including the Steller sea lion (*Eumetopias jubatus*), sea otter (*Enhydra lutris*), harbor seal (*Phoca vitulina*), killer whale (*Orcinus orca*), fin whale (*Balaenoptera physalus*), gray whale (*Eschrichtius robustus*), Dall's porpoise (*Phocoenoides dalli*), and harbor porpoise (*Phocoena phocoena*). Other marine mammal species are known to inhabit these waters; however, sightings are less frequent in the nearshore waters where humpbacks feed.

Killer whales are the only known predators of humpbacks, generally attacking small calves and juveniles (Dolphin, 1987; Naessig & Lanyon, 2004; Mehta et al., 2007; Steiger et al., 2008). Inhabiting the waters of southcentral Alaska are three distinct ecotypes of killer whales: residents, transients (Bigg et al., 1987), and offshores. Resident

and offshore killer whales primarily feed on fish (*Oncorhynchus* spp.); whereas, transient killer whales prey upon other marine mammals (Saulitis et al., 2000; Herman et al., 2005). The most common type of interaction between humpback and killer whales tends to be non-predatory, however the opportunity for predatory interactions are possible (Dolphin, 1987; Jefferson et al., 1991). Under the risk of predation, a humpback whale can engage in a variety of behavioral responses affecting its habitat use over both small and large geographical and temporal scales (Steiger et al., 2008).

The purpose of this study is to examine the relationship between humpback whale associations, including those with conspecifics and heterospecifics (specifically killer whales), and habitat use by documenting behaviors of humpback whales on their feeding ground. The main aquatic predator of humpback whales is the killer whale (Dolphin, 1987; Steiger et al., 2008), which fall into two groups, fish-eating and mammal-eating (Jefferson et al., 1991). Humpbacks will travel with fish-eating killer whales, yet they will mob mammal-eating killer whales (Pitman et al., 2017). It is hypothesized that humpback whales will modulate their behavior based on the presence or absence of killer whales in the study area.

Methods

Study Area

This study was conducted in the Kenai Peninsula region of the Gulf of Alaska including the nearshore waters of Resurrection Bay, Aialik Bay, Harris Bay, and the Northwestern Fjord from May to July 2017 and June to August 2018. These productive, nutrient-rich waters make this location suitable habitat for species of cetaceans and marine carnivores.

All observations were conducted from a whale-watching vessel departing from and returning to the Seward Boat Harbor in Seward, Alaska between the hours of 0800 and 1730 AKDT. Observations were conducted 1-4 days per week aboard catamaran or monohull vessels operated by Kenai Fjords Tours. Data were collected aboard vessels on the Northwestern Fjord Tour (n=31; 20 in 2017; 11 in 2018), a 9-hour tour (~194 km) reaching its midpoint destination at the Northwestern Glacier, or the National Park Tour (n=6 in 2017), a 6-hour tour (~160 km) reaching its midpoint destination at either Holgate Glacier or Aialik Glacier (Figure 1). The main determinate of the vessels general path each day was the specific tour; however, variations in visitation of specific locations depended on captain's preferences, reported sightings from other vessels, and weather. Due to weather related conditions such as dense fog and rough seas, data were collected on fewer tours in 2018 than 2017.

Initial Observations

Marine mammals were sighted by continuously scanning areas around the vessel. When a sighting was made the species was observed closely by L.E.M. with a pair of Zeiss Terra ED 8x42 binoculars (when necessary) and identified based on a number of physical characteristics such as size and coloration, as well as the blow pattern and dorsal fin shape of cetaceans. The number of individuals was recorded immediately after the species had been identified. For cetaceans, the number of individuals was recorded during the first surfacing after the species had been identified. A Garmin GPSMAP 78sc was used to record the location and time of each sighting, as well as the direction of movement of individuals. If the vessel did not approach a sighting, the GPS location was

recorded at the nearest point the vessel reached to the individual(s). When the vessel approached a sighting, the GPS location was recorded when the vessel stopped advancing toward the individual(s). Photographs were taken during as many sightings as possible using an Olympus OM-D EM-1 camera with an Olympus M.Zuiko ED 75-300mm lens. For individual identification purposes, photographs of the ventral side of the flukes of humpback whales, dorsal fins of killer whales, and any physical scars were taken. Information about the life history of an individual was gathered via records and catalogs (North Gulf Oceanic Society, Eye of the Whale Research) of humpback and killer whales in the Kenai Fjords and surrounding areas. Observations were recorded from the location on the vessel that offered the best viewpoint.

Behavior Sampling

Behavioral observations on each sighting began immediately after initial data had been collected. A survey-follow protocol was implemented since the movements of the vessel and the duration of time spent with a particular individual(s) were controlled by factors other than research (Mann, 1999). Surveys allowed patterns of associations, behavior, location, and ecological factors, to be tracked all within a brief period of time (Mann, 1999). Continuous focal group sampling, or predominant group activity sampling, was used to record behavioral states, taken from a humpback whale ethogram (Table 1). Humpback whales were considered ‘associated’ or ‘grouped’ if they were estimated to be within five body lengths of one another and behaving in a coordinated manner (traveling in the same general direction, synchronously surfacing and diving) (Whitehead, 1983; Weinrich, 1991). Incident sampling, also known as all occurrence sampling, was used for

surface active behaviors (breach, chin slap, fluke slap, pectoral fin slap, spyhop). In most cases, individual identities were not immediately known at each surfacing. Typically, the vessel approached within a safe distance of a sighting, permitting sufficient time for data recording. Behavioral observations were terminated when the vessel actively began moving away from the sighting. If the vessel did not approach a sighting, behavioral observations were conducted for as long as possible. Approval from Western Kentucky University's Institutional Animal Care and Use Committee (Animal Welfare Assurance # A3558-01) was obtained prior to the collection of any behavioral data (WKU IACUC 17-08).

Data Entry

Behavioral data collected in the field were recorded on Rite-in-the-Rain paper and later entered into Microsoft Excel (version 16.17). Waypoints that were designated at the time of each sighting were used to match behavioral observations to GPS locations. Locations were converted from the equipment default degrees, minutes, seconds format to decimal degrees in Microsoft Excel using the formula $DD=d+(min/60)+(sec/3600)$. This conversion was necessary to perform spatial analyses.

Statistical Analyses

Spatial and descriptive statistics were used to analyze distribution and abundance patterns of whales in the study site. Spreadsheets for each species were uploaded to ArcGIS Online software by Esri (subscription #6050785290). The 'Ocean' basemap (Sources:

Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors) was selected as the display for all resulting maps.

Humpback and killer whale sightings were mapped according to counts and superimposed to visually examine differences in group size and distribution. Density maps of humpback whales and killer whales were created from the output of the 'Calculate Density' analysis function. Output values were calculated using a kernel density algorithm and were classified using natural breaks with 10 classes. The number of individuals at each sighting was accounted for in density calculations.

To determine if a relationship existed between killer whale occurrence and humpback whale habitat use, a hot spot analysis was performed in ArcGIS (McGovern et al., 2018; Santora et al., 2010) using humpback whale sighting locations on days where killer whales were present and again on days where killer whales were absent. Point counts were used in each hot spot analysis to examine clustering patterns of humpback whale sightings. The 'Find Hot Spots' tool placed a fishnet grid over the point counts and quantified these spatial patterns using the Getis-Ord G_i^* statistic, resulting in z-scores and p-values ($\alpha=0.05$) (Getis & Ord, 1992). Only grid cells that contained at least one humpback whale sighting were displayed in the resulting maps. Since each humpback whale sighting could represent more than one individual, a second set of hot spot analyses were performed to quantify where clusters of large and small groups of humpback whales occurred in the presence and absence of killer whales.

The potential relationship between killer whale occurrence and humpback whale behavior was analyzed using a two-way chi-square test, where the presence and absence of killer whales served as independent variables and the behavior of humpback whales

served as the dependent variable. Humpback whale behaviors included feed, rest, surface active, travel, and unknown. The number of times each behavior was observed in the presence and absence of killer whales filled each respective cell of the 2x5 chi-square table. Using these values, a chi-square test was performed in Microsoft Excel.

Results

Humpback and killer whales were sighted on 100% and approximately 51% of tours, respectively. Other sightings included Dall's porpoise (n=79), fin whale(n=7), gray whale (n=1), harbor porpoise (n=2), harbor seal (n=97), minke whale (n=1), sea otter (n=134), and Steller sea lion (n=135). A total of 251 humpback whale sightings were recorded over the course of the study. Of those sightings, 175 occurred in 2017 and the remaining 76 occurred in 2018. Humpback whale group sizes ranged from 1-6 individuals with an average of 1.47 (± 0.94) and median of 1. Killer whales were sighted a total of 37 times, 30 of which were in 2017. Resident and transient ecotypes were identified on 11 and 3 tours, respectively. Killer whales of unidentified ecotype were observed on 6 tours. Although killer whales were sighted less frequently, they were often observed in larger groups than humpback whales which is to be expected based on the social structure of each species. Killer whale group sizes ranged from 1-12 individuals with an average of 5.03 (± 2.75) and median of 4. These two species were found to have an overlapping distribution in the waters surrounding Kenai Fjords National Park but were never sighted together. Humpback whales spanned a greater portion of the study area and traveled farther into the fjords (Resurrection Bay, Aialik Bay, and Harris Bay) than killer whales (Figure 2).

Maps of species densities revealed small scale differences in habitat preferences between humpback and killer whales. The highest density of humpback whales was estimated near the Chiswell Islands at 3.2-3.8 individuals per square kilometer. As part of the Alaska Maritime National Wildlife Refuge, this island group supports numerous species of nesting seabirds, as well as a Steller sea lion rookery. Humpback whales were also concentrated near Cape Aialik (1.5-2.1 ind./km²), Aligo Point (1.1-1.5 ind./km²), and Cheval Island (1.1-1.5 ind./km²) (Figure 3). In comparison, killer whale density estimates were highest near Cheval Island (1.9-2.2 ind./km²) followed by No Name Island (1.6-1.9 ind./km²), the Chiswell Islands (1.3-1.6 ind./km²), and Aligo Point (1.0-1.3 ind./km²) (Figure 4). For both species, additional locations within the study area were estimated to have species density values less than approximately 1.0 ind./km² (Figure 3, Figure 4)

Further spatial analyses investigating humpback whale distribution patterns suggested differences in humpback whale habitat preferences based on the presence and absence of killer whales in the study area. In the absence of killer whales, statistically significant clustering patterns of humpback whale sightings were found throughout the Chiswell Islands, the location with the highest estimated density of humpback whales. Seventeen grid cells were considered to be statistically significant based on the high number of sightings recorded in each cell (Figure 5). Of those, seven were considered hot spots with 99% confidence, nine were considered hot spots with 95% confidence, and one was considered a hot spot with 90% confidence. The remaining grid cells, where at least one humpback sighting was recorded, were not statistically significant (Figure 5). Killer whale presence in the study area resulted in no statistically significant clustering of humpback whale sightings. No hot or cold spots were identified throughout the entire

area where humpback whale sightings occurred in the presence of killer whales (Figure 6), suggesting the presence of killer whales was related to the dispersion of humpback whales.

Humpback whale group size patterns also appeared to differ with killer whale occurrence, as hot spot analyses were used to specify locations within the study area where large and small groups of humpback whales clustered. Statistically significant clustering was found throughout the Chiswell Islands on days without killer whales. Hot spots ($n=22$) with 90% confidence indicated significantly larger groups of humpback whales occupied areas surrounding the Chiswell Island group (Figure 7). However, in the presence of killer whales, only three hot spots with 90% confidence were identified. These hot spots, located near Cheval Island and Hive Island (one of the barrier islands of Resurrection Bay), were all indicative of statistically significant clustering of large groups of humpback whales (Figure 8). No cold spots were found in either analysis. Interestingly, the waters near Cheval Island account for the highest density of killer whales (1.9-2.2 ind./km²) in the study area.

In addition to spatial distribution patterns, the behavior of humpback whales was examined in relation to the presence and absence of killer whales. Humpback whales were observed in travel (71.3%), feeding (17.5%), surface active (6.4%), rest (2.4%), and unknown (2.4%) behavioral states. There was no evidence that humpback whale behavior was related to the occurrence of killer whales in the study area ($\chi^2 = 5.27$, $df = 4$, $p = 0.26$).

Discussion

Humpback and killer whales demonstrated different geographic distribution patterns in southcentral Alaska's Kenai Fjords. Although their distributions overlapped in some areas, the greatest kernel density estimates for each species were geographically distinct, potentially revealing habitat preferences for these locations. One explanation for these habitat preferences is the dissimilarity in diet between the two species, as well as between the two ecotypes of killer whale observed in this study (resident fish-eaters and transient mammal-eaters), as the dietary specialization of each would drive small-scale movement patterns within the study area toward their respective resources (Saulitis & Matkin, 2000; Hazen et al., 2009). Determining the degree to which prey availability acted as a selective force driving the observed humpback and killer whale distributions would require additional data such as the productivity within Kenai Fjords.

Humpback whale hot spots were identified only in the absence of killer whales and were located throughout the Chiswell Island group, the location with the greatest estimated density of humpback whales. This finding suggests killer whale occurrence may be responsible for the dispersion of humpback whales as no hot spots were identified on days with killer whales. Spatially, clusters of large groups of humpback whales also differed with the occurrence of killer whales. Clusters of large groups shifted from the Chiswell Islands, the preferred habitat of humpback whales, in the absence of killer whales to Cheval and Hive Islands in the presence of killer whales. With the greatest estimated density of killer whales, the waters surrounding Cheval Island may be perceived as a risky area to humpback whales.

Photographs of humpback whale flukes with rake mark scars from killer whale teeth were taken during the course of this study (n=6), two with substantial portions of one or both flukes missing. These individuals were likely calves or juveniles at the time of their attack (Steiger et al., 2008; Naessig & Lanyon, 2004; Mehta et al., 2007) as killer whales would be expected to take advantage of the vulnerability of young animals. Some studies suggest killer whale attacks occur primarily in low latitude breeding regions (Mehta et al., 2007; Steiger et al., 2008) although harassment and predatory attacks have been documented in Alaskan waters (Jefferson et al., 1991; Saulitis & Matkin, 2000).

Predation pressure from killer whales varies greatly between regions in the North Pacific (Steiger et al., 2008). In Kenai Fjords, humpback whales may respond to high perceived risk of predation by altering their movements in an effort to avoid the conceivable threat, or by employing a group defense strategy as described by Whitehead & Glass (1985) when occupying areas of higher perceived risk. These two antipredator responses may explain the discrepancies between humpback whale hot spots and large group clustering, respectively, based on killer whale occurrence.

Ford & Reeves (2008) classified the antipredator behavior of humpback whales as ‘fight’ strategists rather than ‘flight’ strategists in response to killer whale harassment and attacks. However, the rarity of observed attacks raises questions about the generalizability of such classification. It is reasonable to believe the surface activity and splashing associated with humpback whale ‘fight’ responses would make these events more noticeable than ‘flight’ responses. Interestingly, the current study revealed spatial differences in humpback whale distribution and group size patterns while humpback whale behavioral states were unchanged based on the occurrence of killer whales. It is

conceivable that humpback whales responded to the perceived threat by relocating before a ‘fight’ response was necessary.

Humpback whale associations with conspecifics were consistent with the findings of previous studies (Whitehead, 1983; Weinrich, 1991; Weinrich & Kuhlberg, 1991) with one exception; mother and calf pairs were uncommon in Kenai Fjords. Only two calves were recorded in the study area, both in 2018. Some animals may alter their reproductive rates under high predation risk (Lima & Dill, 1990) but there is not enough data from this study to support such a claim. Numerous explanations for the lack of mother-calf associations are plausible including those related to climatic factors, migratory shifts, or perhaps the North Pacific humpback whale population is nearing its carrying capacity as it recovers from historic whaling efforts. While the vast majority of humpback whale associations were intraspecific, one sighting of a humpback and minke whale traveling in close proximity occurred in 2018. The heterospecifics stayed within several body lengths of one another for the duration of the observation. This was the only minke whale sighting over the course of the study and such an uncommon sighting could be the result of perceived predation risk. With such few observations, most being anecdotal, the significance of the role killer whale predation plays on large baleen whale populations remains a topic of great debate in the literature (Springer et al., 2003; Springer et al., 2008; Ford & Reeves, 2008).

Behavioral studies of cetaceans are notoriously challenging for several reasons (Mann, 1999). Cetaceans are aquatic mammals and only a fraction of their behavior occurs at the surface. Observations conducted from a boat are generally limited to sightings made at the water’s surface and a few meters directly beneath the vessel. As

with any cetacean study, sightings may have been missed but given the number of boats in the surrounding area reporting marine mammal sightings via radio, it is unlikely that this was the case for the present study. Cetaceans are also highly mobile and capable of traveling great distances over the duration of each tour. Sightings of individuals or pods of whales more than once per day in different locations were possible. There was also a temporal limitation associated with conducting observations from a tour boat as the boat generally visited the same location around the same time each day (Figure 1). Since the goal of this study was to document humpback whale habitat use in Kenai Fjords, all sightings provided data as to who, how, and when specific areas were being used. Ultimately, this study presents Kenai Fjords as important habitat for humpback whales and acknowledges resource availability as one of the main distribution drivers, but argues that perceived predation risk should not be discounted as a factor affecting humpback whale habitat use on their summer feeding grounds without further research.

Future research should focus on determining if killer whale ecotype is an important factor influencing humpback whale habitat use, as it is unknown whether humpback whales can make that distinction. This has important implications for assessing a perceived predation risk considering transient killer whales are the only ecotype responsible for predatory attacks on large baleen whale species, but other ecotypes exist in Kenai Fjords.

Tables & Figures

Table 1. Humpback whale ethogram including behavioral states and events.¹

States	Events	Abbrev.	Definition
Feed		FE	Whale(s) surface with their mouths open.
Rest		RE	Whale remains stationary in a horizontal position at the surface of the water while periodically raising its head to breath.
Surface Active		SA	Whale(s) are active on the surface of the water.
	Breach	BR	Whale vertically launches more than half of its body out of the water, sometimes spinning in the process, and lands horizontally generating a large splash.
	Chin slap	CS	Whale vertically raises its head out of the water and forcefully strikes the surface of the water with the ventral side of its head, generating a splash.
	Fluke slap	FS	Whale lifts its flukes out of the water and forcefully brings them down, striking the surface of the water and generating a splash.
	Half breach	HB	Whale vertically launches less than half or exactly half of its body out of the water and lands horizontally generating a splash.
	Pectoral slap	PS	Whale strikes the surface of the water with one or both of its pectoral fins.
	Spyhop	SH	Whale vertically raises its head out of the water so that both eyes are above the surface of the water.
Travel		TR	Whale is moving in a specific direction with a clear pattern of blows and dives.
	Blow	BL	Whale surfaces with its blowhole out of the water and forcefully exhales, shooting a mist into the air.
	Dive	DV	Whale arches its tail stock and submerges underwater. Flukes maybe raised so that the ventral side is visible to an observer positioned posterior to the whale.
Unknown		UK	The behavior of the whale cannot be determined.
Other		OT	Whale is engaged in a behavior that is not listed above.
Not Visible		NV	Direct observation of the whale is not possible.

¹ Whale and Dolphin Conservation [WDC]. (2003). *WDC Ethogram - Humpback whale behavior*.



Figure 1. Map of study area and tour routes courtesy of Kenai Fjords Tours.

Approximate timing (AKDT) of the Northwestern Fjord Tour is displayed on along the black route.

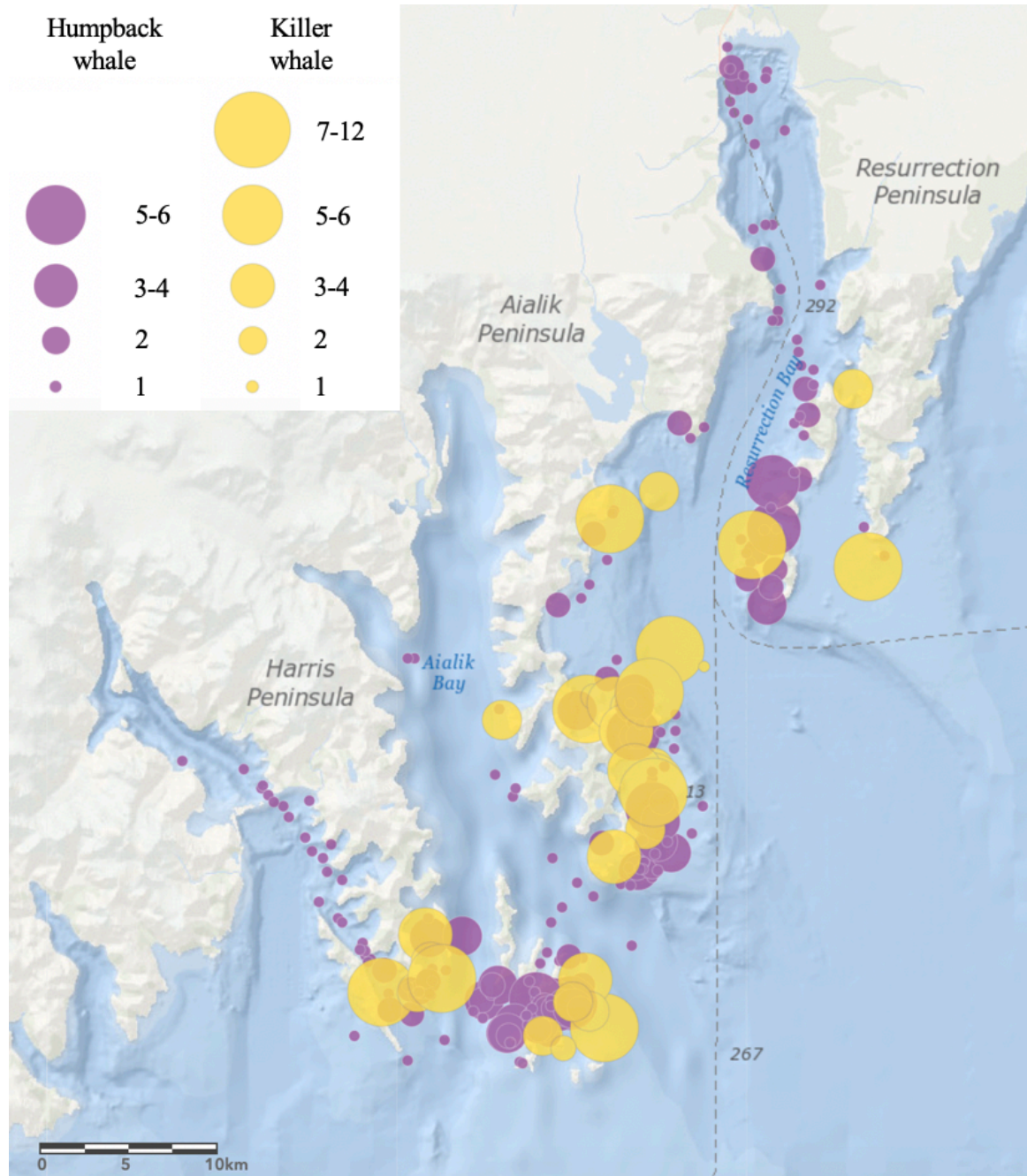


Figure 2. Map of humpback whale (purple) and killer whale (yellow) sightings. The size of each circle is representative of the group size for each sighting. See Figure 1 for location details.

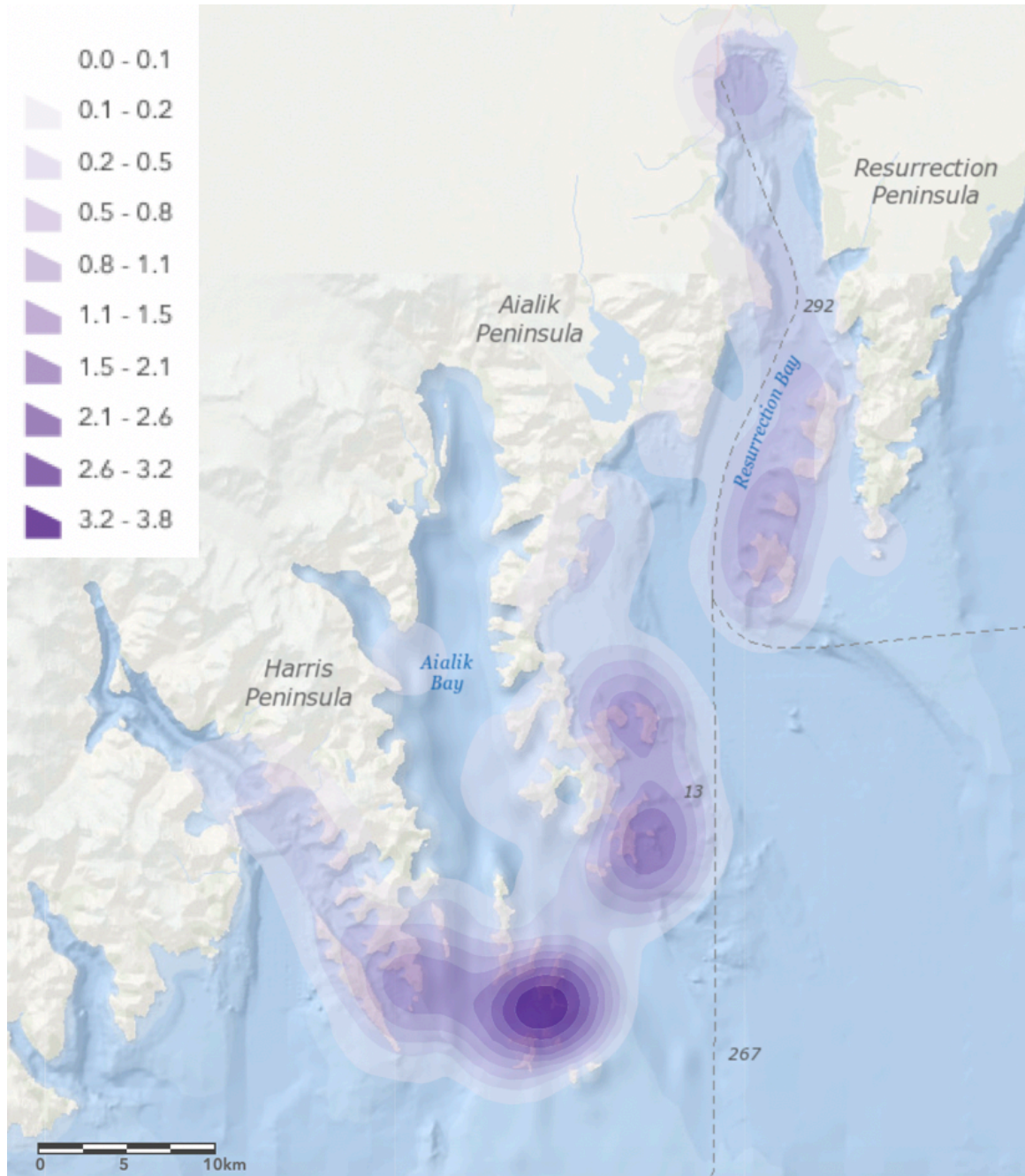


Figure 3. Density map of humpback whales in the study site (individuals per square kilometer). See Figure 1 for location details.

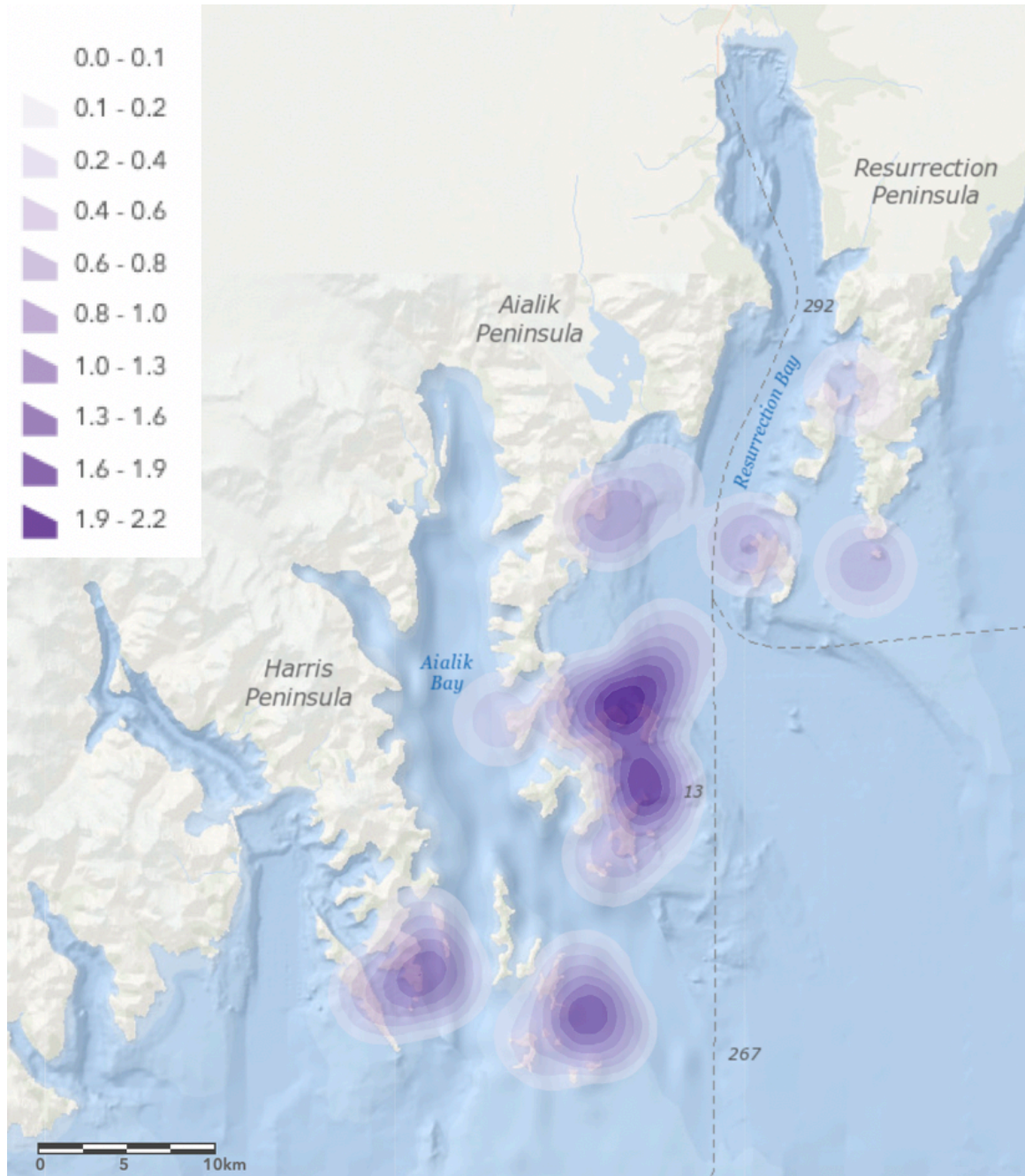


Figure 4. Density map of killer whales in the study area (individuals per square kilometer). See Figure 1 for location details.

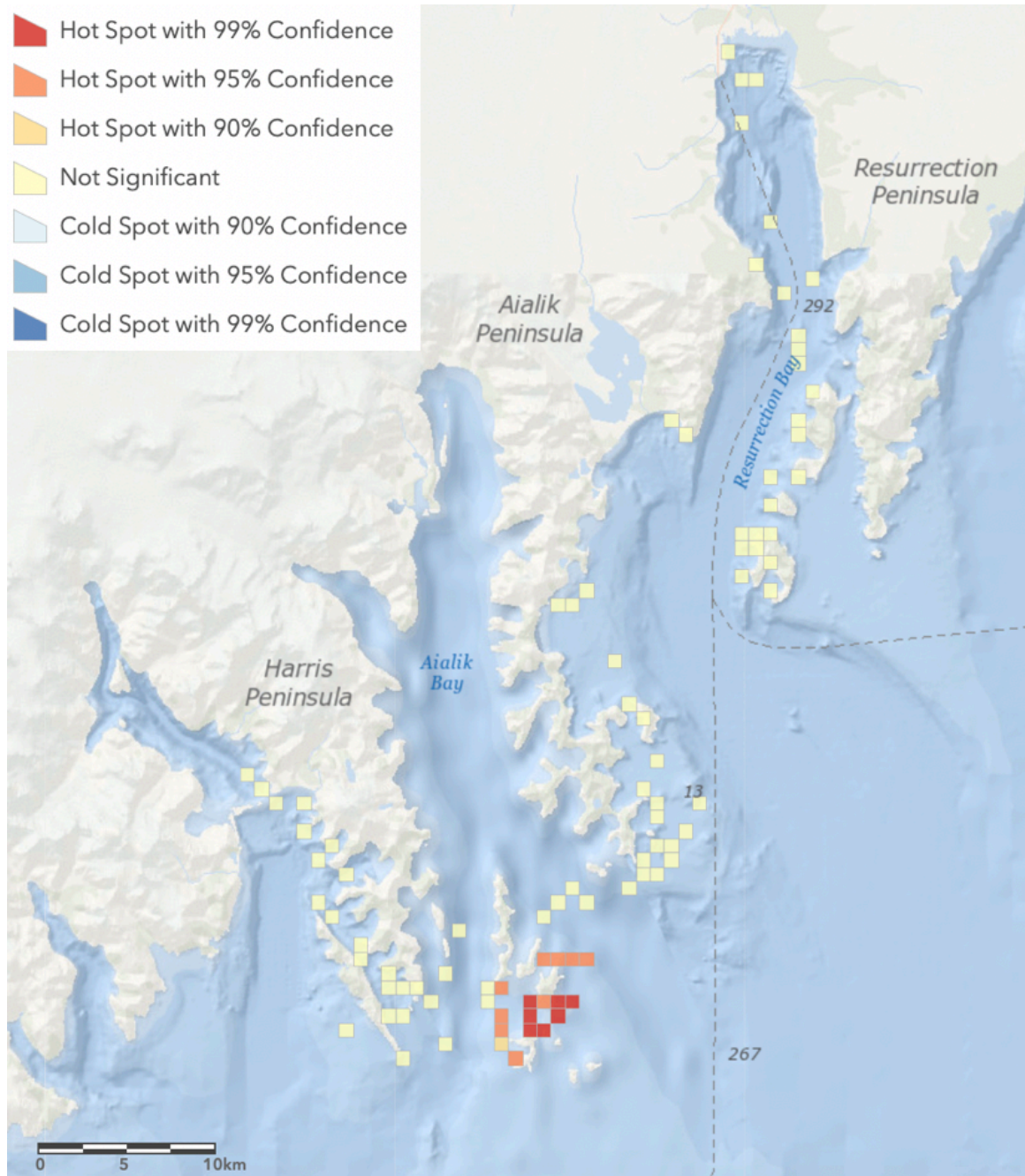


Figure 5. Humpback whale hot spot analysis map in the absence of killer whales. See Figure 1 for location details.

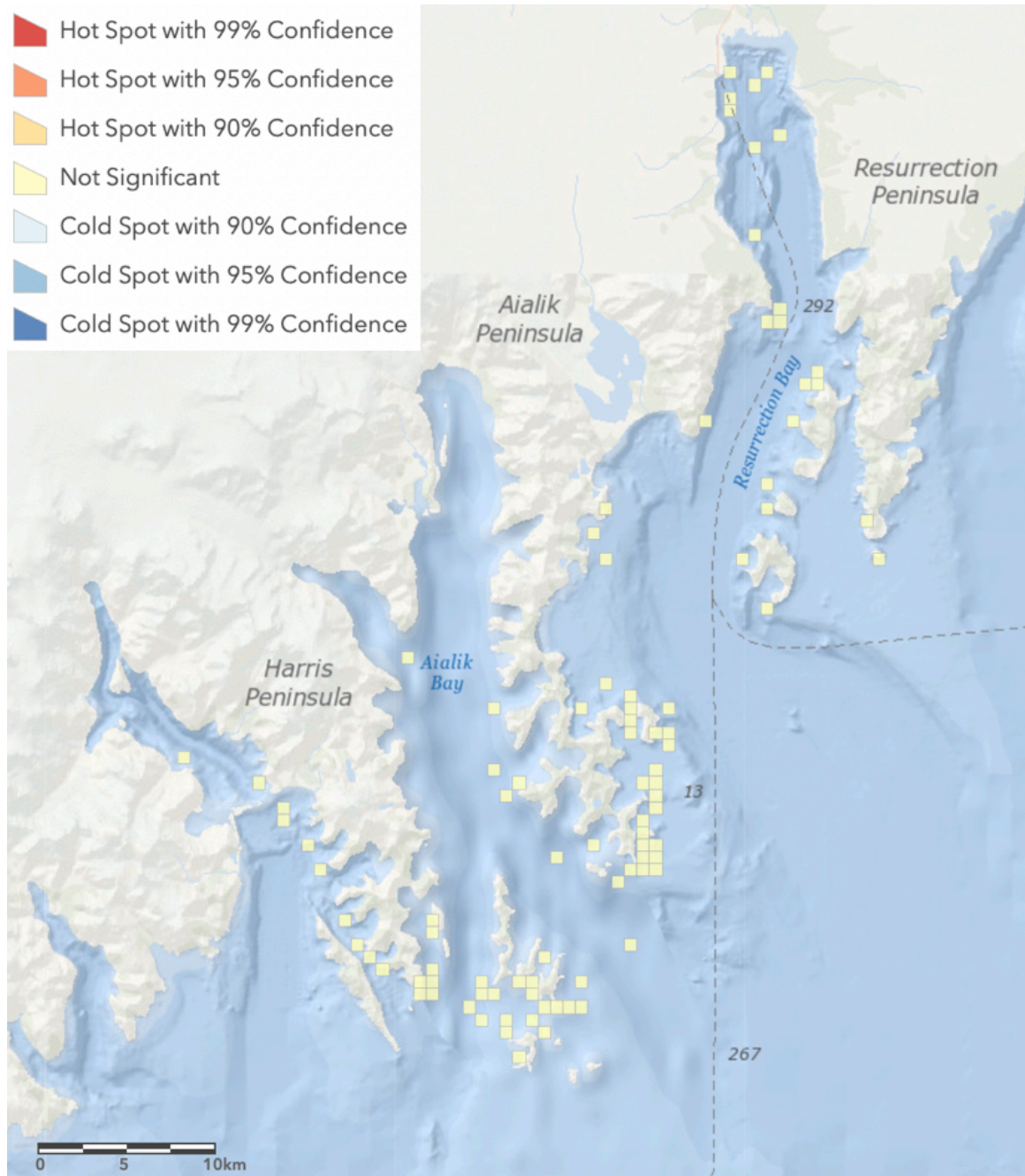


Figure 6. Humpback whale hot spot analysis map in the presence of killer whales (No significant hots or cold spots were found). See Figure 1 for location details.

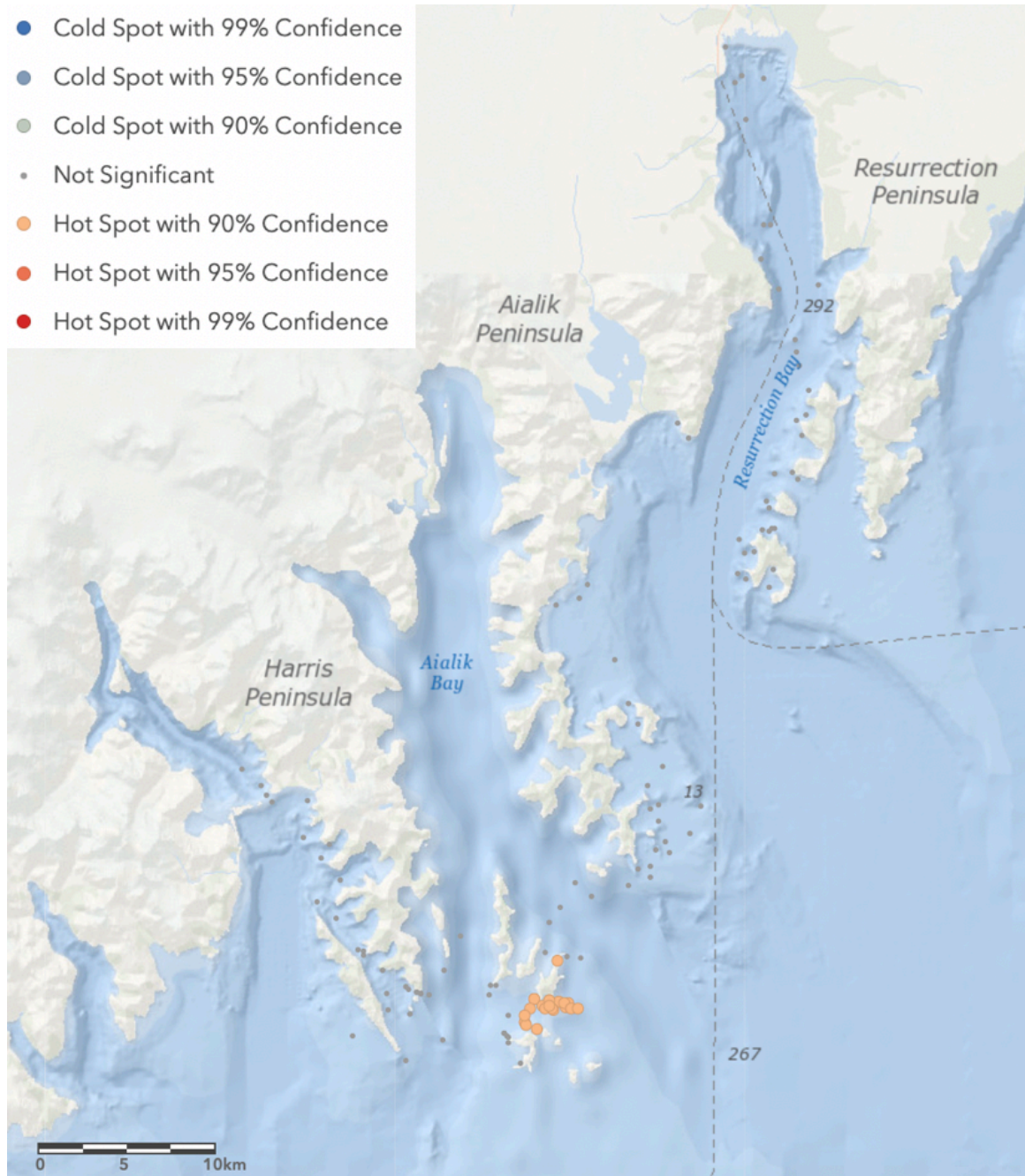


Figure 7. Humpback whale hot spot analysis map showing group size clustering in the absence of killer whales. See Figure 1 for location details.

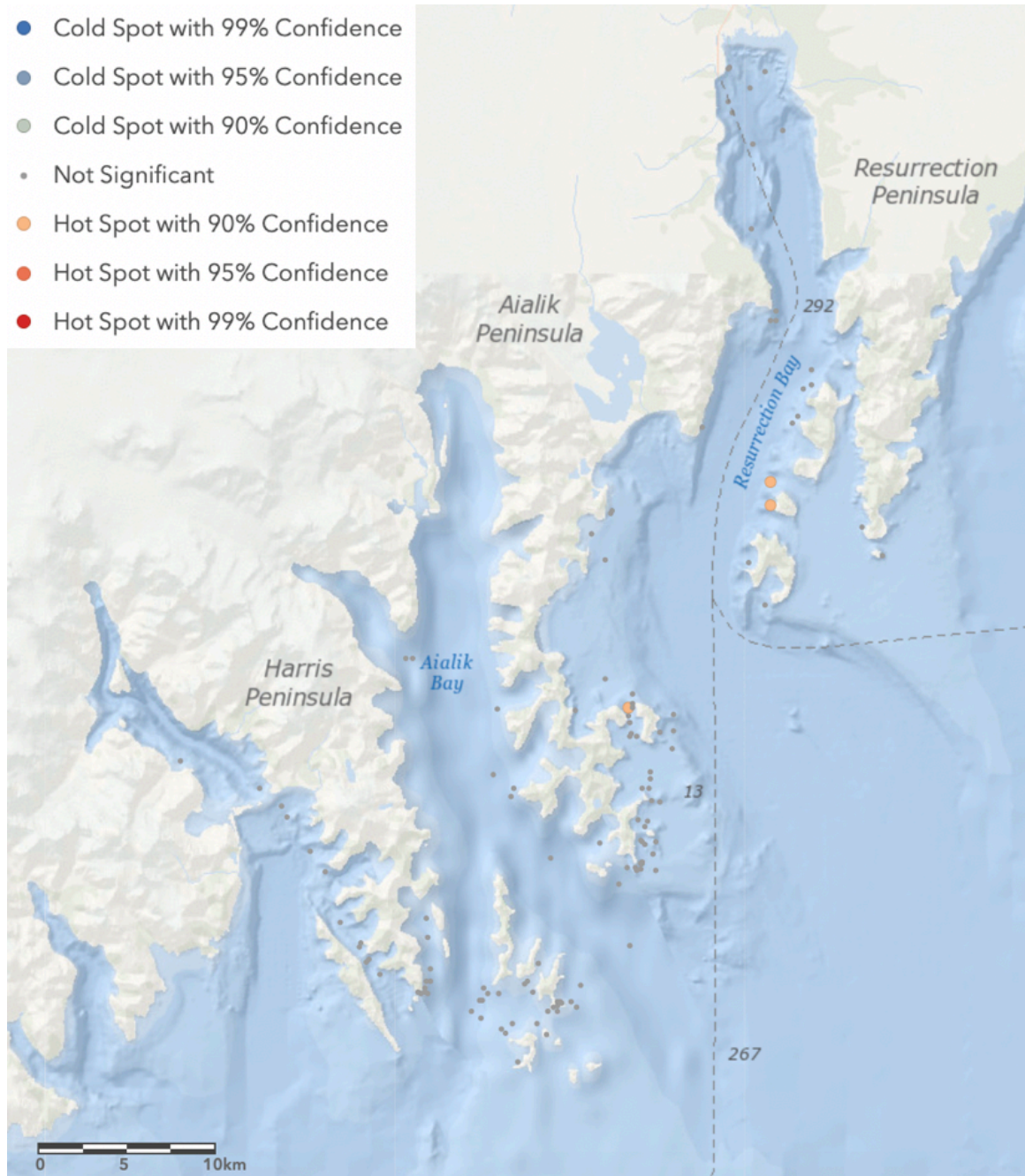


Figure 8. Humpback whale hot spot analysis map showing group size clustering in the presence of killer whales. See Figure 1 for location details.

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CHAPTER 2

EFFECTS OF WHALE WATCHING ON PASSENGER CONSERVATION ATTITUDES IN KENAI FJORDS, ALASKA

Introduction

Whales have been exploited by humans for centuries but with the creation of the International Whaling Commission in 1946 and their implementation of a moratorium on commercial whaling in 1982, an alternative use for whales, whale watching, has gained popularity (Cisneros-Montemayor, Sumaila, Kaschner & Pauly, 2010). The global whale watching industry was estimated to be growing at an average rate of 3.7% per year (as of 2008) and is capable of generating a multibillion dollar expenditure (Cisneros-Montemayor et al., 2010; O'Connor, Campbell, Cortez, & Knowles, 2009). Hosting nearly half of all whale watchers in 2008, North America is considered the largest whale watching region in the world, although the average annual growth rate for this region has declined since 1994 (O'Connor et al., 2009). While many countries have already realized the economic benefits of whale watching, the full potential for this industry has not yet been reached (Cisneros-Montemayor et al., 2010; Raschke, 2017).

In Alaska, the commercial whale watching industry targets cetaceans during the summer months when both seasonal and year-round species are present (O'Connor et al., 2009). The influx of migratory species such as the gray whale (*Eschrichtius robustus*) and humpback whale typically mark the start of the season, which lasts for approximately four months. Alaska is a particularly attractive destination for whale watchers due to the presence of both humpback and killer whales (*Orcinus orca*), which are known for their

aerial behaviors (O'Connor et al., 2009). Other species of cetaceans, marine carnivores, and seabirds can also be seen. In 2008, Alaska's whale watching industry was estimated to be worth more than \$4.6 million and growing at an average rate of 21% per year (O'Connor et al., 2009). Two commercial whale watching companies offer daily tours marketed as wildlife and glacier cruises in Seward, Alaska. Passengers include those from cruise ships, smaller ecotourism groups, and other independent tourists (O'Connor et al., 2009).

The growth whale watching raises important questions regarding the sustainability and impact of this industry on whales (O'Connor et al., 2009). While generally considered a non-consumptive activity, numerous studies compiled by Parsons (2012) have documented a variety of behavioral changes of cetaceans (whales, dolphins, and porpoises), including but not limited to those related to respiration, communication, distribution and movement patterns, feeding, and resting, in response to boat-based whale watching activities. Collectively, these short-term behavioral changes have the potential to reduce the fitness of individuals, which can be detrimental to entire populations (Bejder et al., 2006; Parsons, 2012). Some have even proposed whale watching should be considered a form of non-lethal consumptive exploitation (Higham, Bejder, Allen, Corkeron & Lusseau, 2015). As the industry grows and requires more vessels to enter the water, both direct and indirect effects of whale watching remain a great concern (Parsons, 2012). Regardless of its classification, adopting responsible and sustainable whale watching practices is the most obvious and practical solution to help alleviate the potential negative effects of this industry on cetacean populations (Corkeron, 2006; Parsons, 2012).

Sustainable whale watching initiatives usually involve the establishment of rules and regulations; however, there is great variation among whale watching codes of conduct (Garrod & Fennell, 2004; Parsons, 2012). Ranging from nonvoluntary regulations to voluntary guidelines or suggestions written by governments, nongovernmental organizations, and the industry (Garrod & Fennell, 2004), these codes are often designed to be species and location specific. A review and analysis of international whale watching codes of conduct found the majority of them to be voluntary (62%) while the remaining were regulatory (38%) (Garrod & Fennell, 2004). Hoyt (2005) highlighted the need for a more methodical approach to the management of the industry and recommended the establishment of marine protected areas to ensure its long-term sustainability. However, compliance with rules and regulations regarding a vessels approach and interaction with cetaceans is often challenging to assess and/or enforce (Parsons, 2012).

The educational value of whale watching also contributes to the sustainability of the industry (Garrod & Fennell, 2004). Whale watching has a demonstrated ability to educate passengers about and promote the conservation of marine mammals (Garcia-Cegarra & Pacheco, 2017; Lopez & Pearson, 2017), although increases in passenger knowledge as a result of whale watching may not be long lasting (Stamation, Croft, Shaughnessy, Waples & Briggs, 2007). The presence of informed interpreters that provide educational commentary during whale watching tours, however, can enhance the educational and conservation value to help ensure lasting effects (Andersen & Miller, 2006; Garcia-Cegarra & Pacheco, 2017; Stamation et al., 2007). Other factors influencing conservation attitudes of passengers include vessel and tour accommodations as well as

passenger demographics (Garcia-Cegarra & Pacheco, 2017; Lopez & Pearson, 2017; Orams, 2000). Additionally, the presence and behavior of whales are important determinates of whale watching satisfaction, having the potential to affect conservation attitudes (Lopez and Pearson 2017; Orams 2000). For example, Orams (2000) reported large numbers of whales and more spectacular whale behavior were responsible for more enjoyable tours. As such, it is critical for the industry to educate passengers and identify factors associated with positive conservation attitudes in order to promote and carry out sustainable practices (Andersen & Miller, 2006).

The purpose of this study is to quantify how marine mammal behavior and habitat use influence the conservation perspectives of whale watching passengers in Kenai Fjords, Alaska. It is hypothesized that a relationship exists between the appeal of particular species and behaviors (e.g., whales breaching or hunting) and conservation attitudes (e.g., more sightings of high appeal behaviors result in greater appreciation of the species). Cetacean species and behavior are hypothesized to be important factors influencing conservation attitudes of whale watching passengers. Understanding the relationship between these factors could provide insight to guide the continued movement to educate people and conserve marine mammals.

Methods

Data Collection

To examine the relationship between whale watching and conservation attitudes toward marine mammals, paper surveys modified from Lopez and Pearson (2017) were administered to consenting passengers (age 18yrs+) aboard whale watching vessels

operated by Kenai Fjords Tours out of Seward, AK. Kenai Fjords Tours has been a voluntary participant of the Whale SENSE program since 2017, a program sponsored by NOAA Fisheries and the Whale and Dolphin Conservation to promote responsible whale watching practices. Surveys were administered 1-2 days per week from May to July 2017 and June to August 2018 between the hours of 0800 and 1730 AKDT. All participants were passengers on the Northwestern Fjord Tour, a 9-hour tour (~194 km) reaching its midpoint destination at the Northwestern Glacier, or the National Park Tour, a 6-hour tour (~160 km) reaching its midpoint destination at either Holgate Glacier or Aialik Glacier (Figure 1). The captain and deckhands provided onboard narration and commentary. Tour vessels were permitted to carry approximately 136 to 150 passengers, depending on the specific vessel, although they were not always filled to capacity.

During the 2017 field season, preliminary data were collected from passengers using a matched pre and post survey method. A pre-survey was administered to passengers within the first hour of the tour and a post-survey was administered to passengers within the last hour of the tour. Typically, few marine mammal sightings occur within the first hour and most sightings have occurred by the last hour of each tour. Although there is great value in this survey design, it was logistically challenging to carry out on a whale watching vessel for several reasons. First, in an effort to prevent surveys from flying overboard and becoming marine debris, survey administration was limited to passengers inside the vessel's cabin. Due to the general excitement and eagerness to see wildlife, most passengers were on outside decks during the period of time when pre surveys were administered. Second, during post survey administration, passengers were often tired and sometimes asleep. It was not always possible to collect matched surveys

since passengers who completed a pre survey were not always available or willing to complete a post survey and vice versa. Efforts were taken to shorten the survey, but response rates remained consistently lower for post surveys.

Based on these factors, a revised version of the survey was created for the 2018 field season. This survey followed a retrospective pre and post design that was only presented to passengers during the last hour of whale watching tours. After the second survey administration, the presentation order was switched from post then pre to pre then post. Participants were asked to complete the surveys as individuals rather than as a group. This survey required participants to respond to multiple types of questions including Likert scale and multiple choice. Participants were asked to respond to questions about their knowledge, attitudes, and behaviors as these factors provide the framework for understanding conservation involvement (Lück, 2003; Zeppel & Muloin, 2009). Surveys were approved by Western Kentucky University's Institutional Review Board prior to their administration (IRB 1081797-2).

In addition to collecting human survey data, all marine mammal sightings that occurred during whale watching tours were documented. Recorded data included species, number of individuals, and the behavior of the animal(s). A pair of Zeiss Terra ED 8x42 binoculars were used to observe marine mammals at each sighting and gather information.

Statistical Analyses

Behavioral and survey data were recorded on paper and later entered into Microsoft Excel (version 16.17). Descriptive statistics (mean \pm SD, percentages) were

used to summarize data such as passenger demographics, satisfaction, and pro-environmental behaviors. Microsoft office Excel was used to calculate measures of frequency and produce figures. Four paired Wilcoxon signed rank tests with a continuity correction were performed in RStudio (version 1.1.456) to determine whether or not passenger knowledge and conservation attitudes differed before versus after whale watching. The sizes of these differences were evaluated using Cohen's d effect sizes. Since three survey questions were related to passenger conservation attitudes toward marine mammals, a Cronbach's alpha test estimated their internal consistency and differences in conservation attitude scores were averaged for each passenger. To quantify the influence of a particular cetacean species on conservation attitude change, passengers were grouped based on whether or not they observed a high appeal species, the killer whale, on their whale watching tour and a Mann-Whitney test was performed on the change in conservation attitude scores between groups. Similarly, a Mann-Whitney test was used to quantify the relationship between high appeal cetacean behaviors (feed, surface active, boat interaction) and the change in passenger conservation attitudes between groups. Due to differences in survey questions and scales between the two field seasons, only data from 2018 were analyzed and reported. Non-parametric statistics with an alpha value of 0.05 were used since the data did not meet normality assumptions.

Results

Surveys were analyzed from seven whale watching tours in 2018 (n=140). About three fourths (78%) of all participants were United States nationals. Residency was broken down into six categories: Asia, Europe, North America, Oceania, South America,

and unknown, representing 6%, 7%, 63%, 1%, 1%, and 22% of survey participants, respectively (Figure 2). The race or ethnicity of participants were Asian/Pacific Islander (14%), Hispanic or Latino (1%), Native American (1%), White/Caucasian (74%), other (2%), and unknown or the passenger preferred not to answer (8%) (Figure 3).

Approximately 59% self-identified as female, 37% self-identified as male, and the remaining 4% was attributed to passengers who preferred not to answer. Ages ranged from 18 to 60+ with 11% being 18-25 years, 29% being 26-40 years, 28% being 41-60 years, 30% being over 60 years, and 2% being unknown (Figure 4).

Passengers were presented with four statements, one regarding knowledge about marine mammals and three regarding conservation attitudes toward marine mammals, and asked to score their agreement with each statement on a 1-5 Likert scale (1- strongly disagree, 2- disagree, 3- neither agree nor disagree, 4- agree, 5- strongly agree) both before and after whale watching tours. A statistically significant difference between before and after scores was found in response to the statement “I am knowledgeable about marine mammals” ($df=132$, $p=4.56e^{-16}$, Table 1). With a mean difference of 0.69 (± 0.69), passengers reported an increase in knowledge after whale watching. In addition, statistically significant differences between conservation attitudes before and after tours were found in response to the statements “marine mammal conservation is important to the survival of marine mammal species” ($df=133$, $p=6.43e^{-4}$), “marine mammal conservation should be scientifically studied” ($df=133$, $p=4e^{-3}$), and “marine mammal conservation can benefit humans” ($df=132$, $p=3e^{-3}$). Mean differences for the three conservation statements were calculated to be 0.18 (± 0.57), 0.16 (± 0.56), and 0.16 (± 0.58), respectively, indicating more positive conservation attitudes after whale

watching (Table 1). Effect sizes were calculated to be 0.82, 0.28, 0.25, and 0.22, respectively (Table 2). These results suggest whale watching is an effective platform for education about and conservation of marine mammals.

A high degree of internal consistency between the conservation attitude statements was found ($\alpha=0.9$), allowing the three difference in conservation attitude scores to be combined into one average score for each participant. With this, Mann-Whitney tests performed to determine the influence of high appeal species and behaviors on changes in conservation attitudes resulted in no statistical significance. Seeing killer whales, deemed to be a high appeal species, did not contribute to changes in conservation attitudes of passengers ($W=1674$, $p=0.491$). Average change in conservation attitude scores were calculated to be $0.117 (\pm 0.34)$ for participants who observed killer whales ($n=37$) and $0.199 (\pm 0.55)$ for those who did not ($n=96$). Likewise, seeing high appeal behaviors did not contribute to changes in conservation attitudes of passengers ($W=1252.5$, $p=0.8$). Participants who observed cetacean surface activity, feeding, or boat interactions were found to have an average change in conservation attitude score of $0.174 (\pm 0.50)$ ($n=111$) versus an average change in conservation attitude score of $0.182 (\pm 0.50)$ for those who did not ($n=22$). For both species and behaviors, the direction of change in average conservation attitudes were positive.

A majority of participants reported being pleased with their whale watching experience. On a 1-5 Likert scale, 98% of participants reported being satisfied or very satisfied with their overall experience. In relation to species and behaviors, 96% of participants reported being satisfied or very satisfied with the number of marine mammal species observed and 94% reported being satisfied or very satisfied with the diversity of

marine mammal behaviors observed (Table 3). Being respectful of the animals was considered the main determinant of the quality of whale watching tours, followed by seeing many species throughout the tour, seeing interesting behaviors, and being close to the animals (Figure 5).

Of the survey participants, 89% were likely or extremely likely to engage in more environmentally friendly activities and 95% were likely or extremely likely to share their knowledge about marine mammals (Table 3). The vast majority of survey participants were satisfied with the experience and whale watching made positive contributions to their knowledge and conservation attitudes with 50% of participants reported being likely or extremely likely to become involved in a marine mammal or conservation issue (Table 3, Figure 6).

Discussion

Passenger conservation attitudes toward marine mammals were positively influenced by whale watching. Although conservation attitudes were generally positive before whale watching, they were significantly more positive afterwards. However, this difference could not be attributed to cetacean species or behaviors, as the occurrence of high appeal species and behaviors did not result in a greater change in attitude as hypothesized. Quantifying the effects of these two factors on passenger conservation attitudes is difficult since species and behaviors likely do not act independently but rather collectively. Nevertheless, these findings are promising for the ability of whale watching to promote marine mammal conservation through changes in passenger conservation attitudes.

Whale watchers were also significantly more knowledgeable about marine mammals after participating in a whale watching tour. This increase in knowledge was likely due to the narration and interpretation provided during the whale watching tour. Numerous studies have recognized the educational value of whale watching and emphasized the importance of onboard, informed interpreters (Garcia-Cegarra & Pacheco, 2017; Lopez & Pearson, 2017; Lück, 2003; Zeppel & Muloin, 2009). Based on the theories of cognitive dissonance and the affective domain, increasing passenger knowledge about marine mammals and providing effective interpretation are fundamental aspects of whale watching (Lück, 2003; Zeppel & Muloin, 2009).

The majority of passengers were at least somewhat likely to engage in more pro-environmental behaviors and about half of participants were likely to get involved in a marine mammal or conservation issue. These results were higher than expected given that a similar study reported 40-50% of boat-based whale watchers would engage in more environmentally friendly behaviors, depending on the specific activity, while only 23% would become involved in helping an environmental group (Stamation et al., 2007). Social desirability bias is often a concern with self-report measures and may contribute to the seemingly elevated percentages reported in this study. It is also important to realize that only intentions were measured. However, these numbers are not unreasonable since passenger satisfaction was also very high.

A number of factors influenced the quality of the whale watching experience. Of utmost importance was being respectful of the animal(s). Interestingly, factors related to species and behaviors, which were not found to prompt changes in conservation attitudes, were among the top determinates of the quality of the whale watching experience. The

latter finding is consistent with conclusions of Orams (2000), indicating whale presence and behavior were related to passenger satisfaction. The responses by participants in the present study suggest that being close to the animal(s) may be more important than previously determined by Orams (2000), which is curious since proximity and respect are conflicting. A study that surveyed humpback whale watchers off Sydney, Australia found similar results in that boat-based whale watchers showed concern for the well-being of whales by indicating the strongest preference for minimizing boat impacts on whales but they also preferred getting closer to the whales than the permitted approach distance (Kessler, Harcourt, & Bradford, 2014). If being respectful of the whales is truly more important to whale watchers than proximity as the current study and Kessler, Harcourt, and Bradford (2014) conclude, it is suggested that whale watching operators can aid in conservation efforts by prioritizing the well-being of whales without jeopardizing passenger satisfaction.

The findings of the present study add to the growing literature guiding the continued movement to educate people and conserve marine mammals. Most of the research about the educational and conservation value of whale watching has focused on the effects of interpretation strategies (e.g. Zeppel & Muloin, 2009), while the effects of the presence and behavior of whales on conservation attitudes has received little attention. As charismatic megafauna, there is great potential for the whales themselves to elicit positive conservation attitudes (Albert, Luque & Courchamp, 2018). Future studies should consider interviewing passengers after each sighting in an effort to identify specific wildlife related factors that may influence conservation attitudes. Additional consideration should be given to the survey administration as the present study

encountered issues with participants improperly filling out survey questions (e.g., marking more than one response when asked for only one) or not completing all survey questions. Follow-ups with participants to determine the lasting effects of whale watching and efforts to minimize sources of bias are also be recommended.

Tables & Figures

Table 1. Paired Wilcoxon signed rank tests with a continuity correction assessing changes in knowledge and conservation attitudes of passengers before and after whale watching during the 2018 field season. Shown are degrees of freedom (df), sum of ranks assigned to the differences, and associated p-values.

	df	Mean difference \pm SD (1-5 Likert scale)	Sum of ranks	p-value
I am knowledgeable about marine mammals	132	0.69 (\pm 0.69)	3897.5	<0.01
Marine mammal conservation is important to the survival of marine mammal species	133	0.18 (\pm 0.57)	283	<0.01
Marine mammal conservation should be scientifically studied	133	0.16 (\pm 0.56)	196	<0.01
Marine mammal conservation can benefit humans	132	0.16 (\pm 0.58)	151.5	<0.01

Table 2. Cohen's d effect sizes for changes in passenger knowledge and conservation attitudes before versus after whale watching.

	n	Mean before ± SD (1-5 Likert scale)	Mean after ± SD (1-5 Likert scale)	Cohen's d
I am knowledgeable about marine mammals	133	3.17 (±0.93)	3.86 (±0.74)	0.82
Marine mammal conservation is important to the survival of marine mammal species	134	4.64 (±0.72)	4.82 (±0.53)	0.28
Marine mammal conservation should be scientifically studied	134	4.66 (±0.69)	4.81 (±0.54)	0.25
Marine mammal conservation can benefit humans	133	4.59 (±0.78)	4.75 (±0.62)	0.22

Table 3. Summary of passenger responses including sample size (n), mean, and standard deviation (SD). Likert scales were used to report satisfaction (1- very dissatisfied, 2- dissatisfied, 3- neither satisfied or dissatisfied, 4- satisfied, 5- very satisfied) and likeliness scores (1- extremely unlikely, 2- unlikely, 3- neutral, 4- likely, 5- extremely likely).

	n	Mean (1-5 Likert scale)	SD
Overall satisfaction	137	4.69	±0.51
Satisfaction with the number of marine mammal species observed	137	4.61	±0.60
Satisfaction with the diversity of marine mammal behaviors observed	137	4.52	±0.65
Likelihood to do more environmentally friendly activities	136	4.51	±0.69
Likelihood to tell friends/family about what you learned	136	4.67	±0.57
Likelihood to get involved in a marine mammal or conservation issue	137	3.50	±1.14



Figure 1. Map of study area and tour routes courtesy of Kenai Fjords Tours.

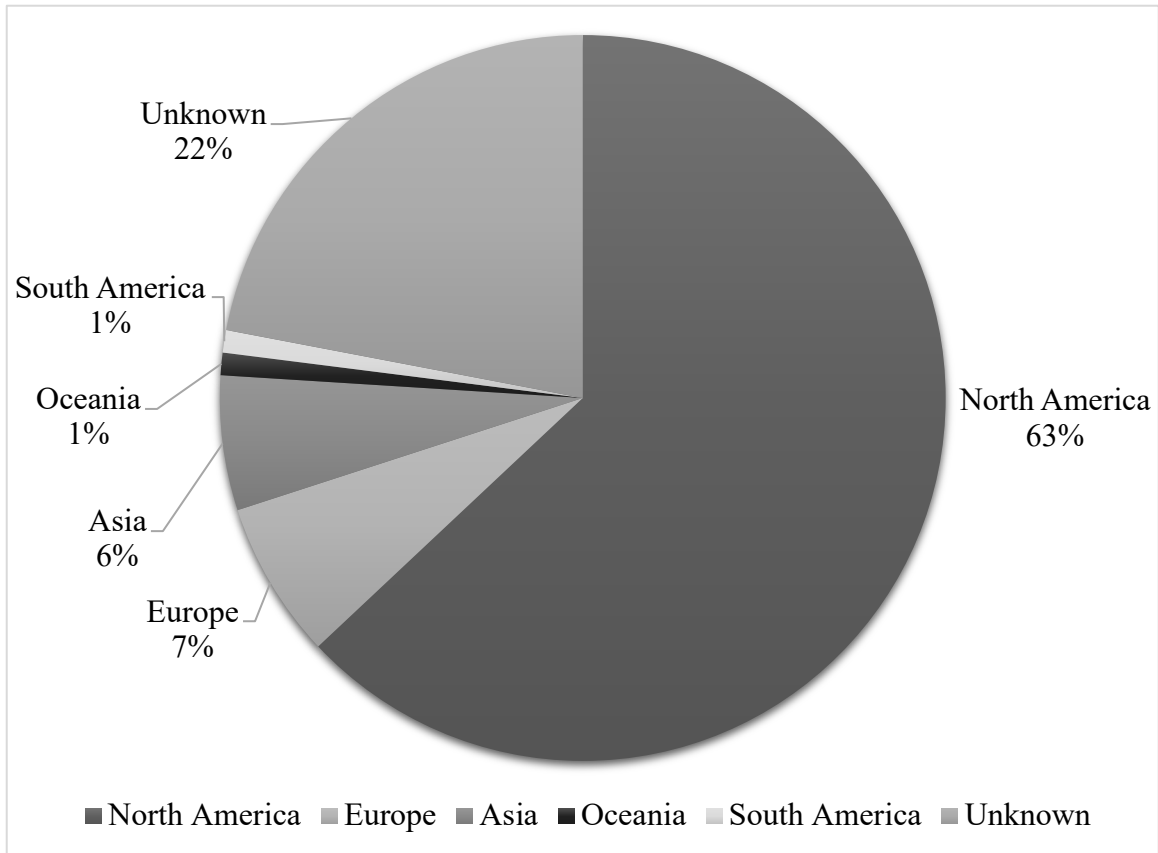


Figure 2. Residency of participants aboard whale watching vessels.

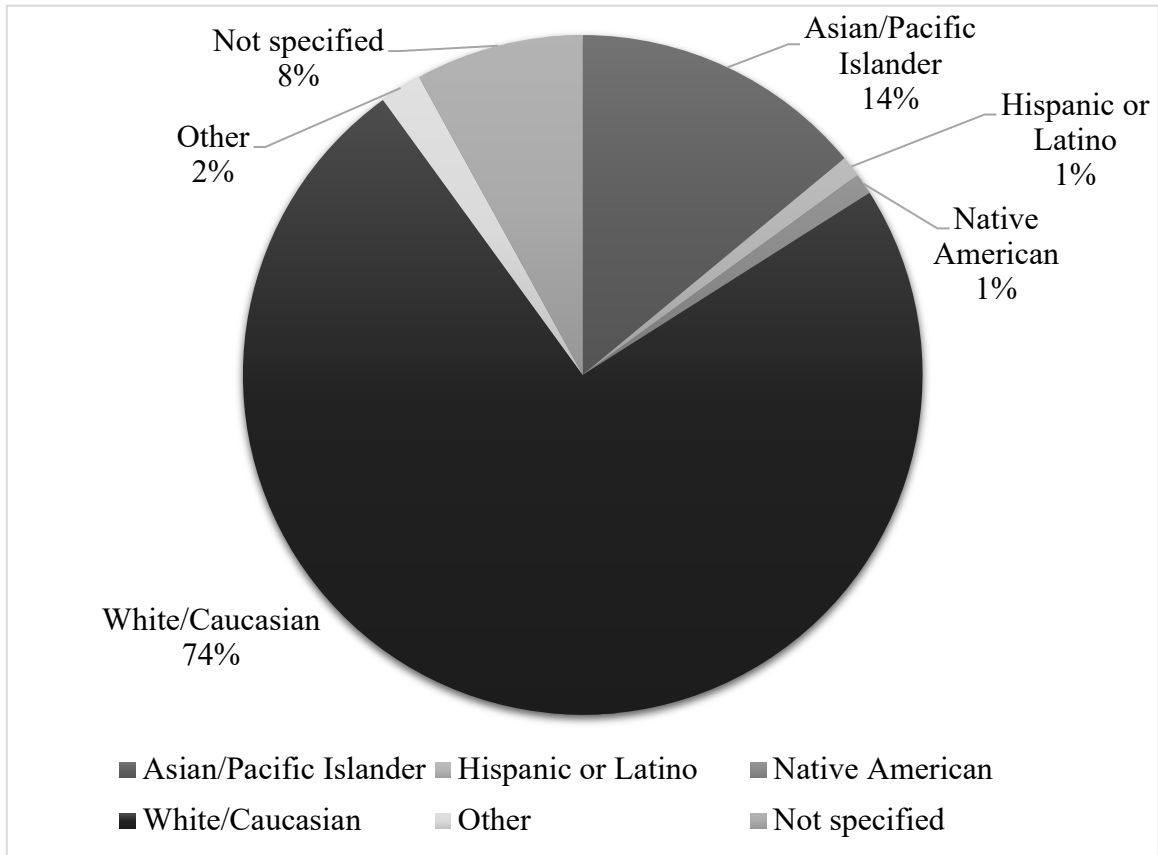


Figure 3. Race/ethnicity of participants aboard whale watching vessels.

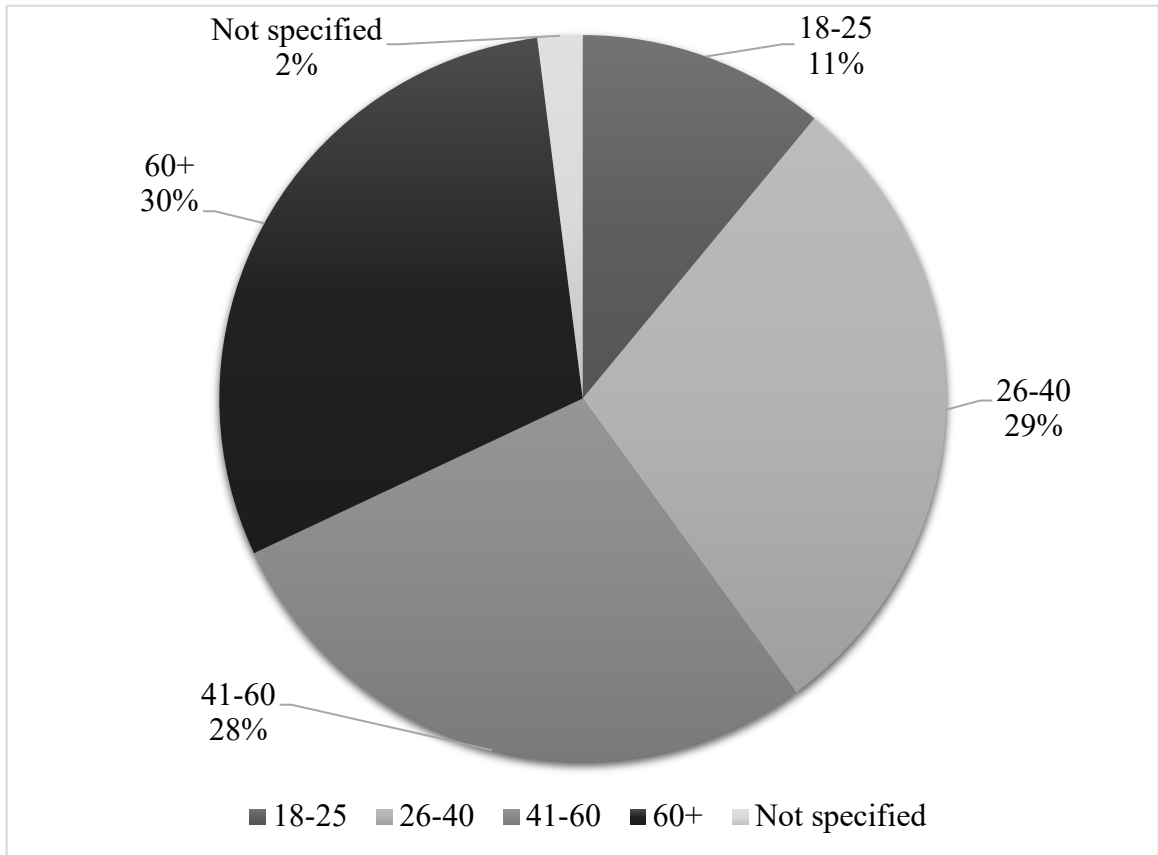


Figure 4. Age of participants aboard whale watching vessels.

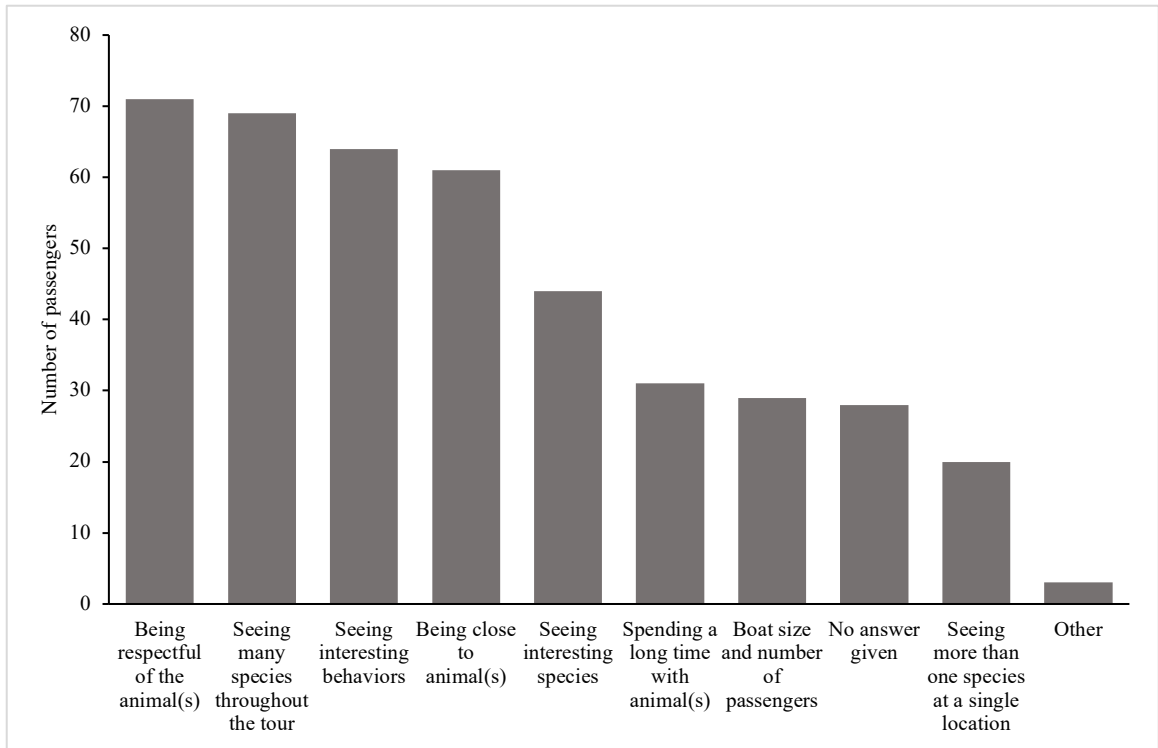


Figure 5. Determinants of whale watching quality.

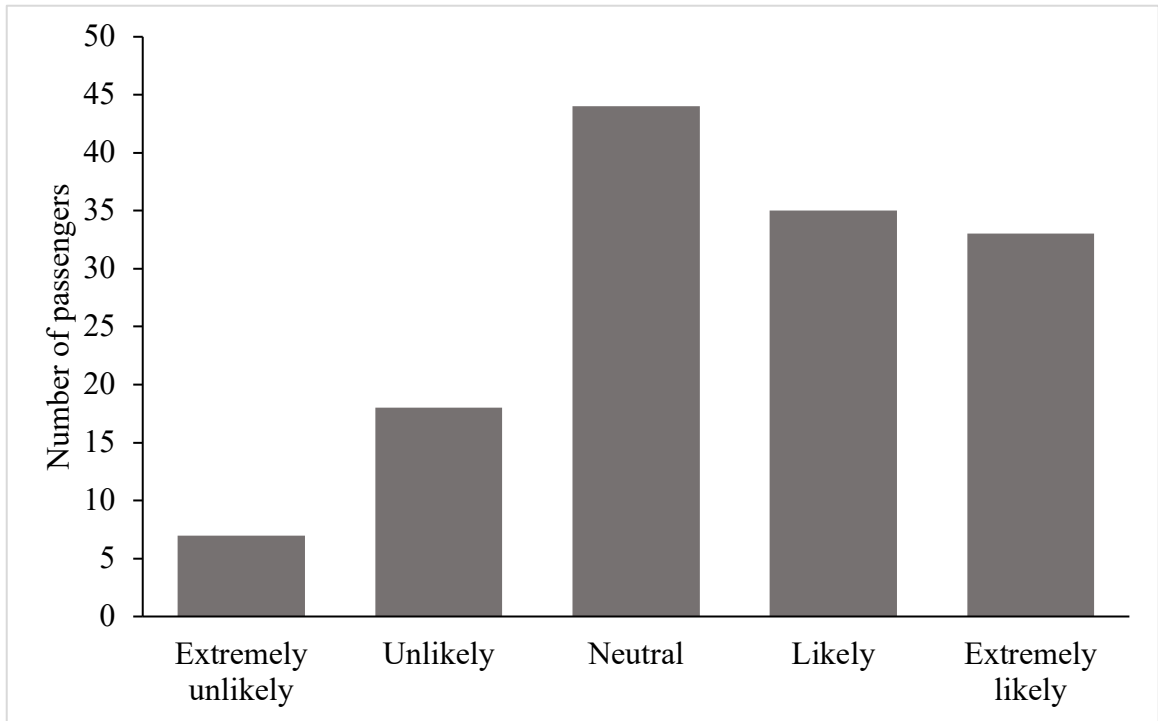


Figure 6. Whale watcher likeliness to get involved in a marine mammal or marine conservation issue such as joining a conservation organization, volunteering, or supporting conservation initiatives after participating in a whale watching tour.

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